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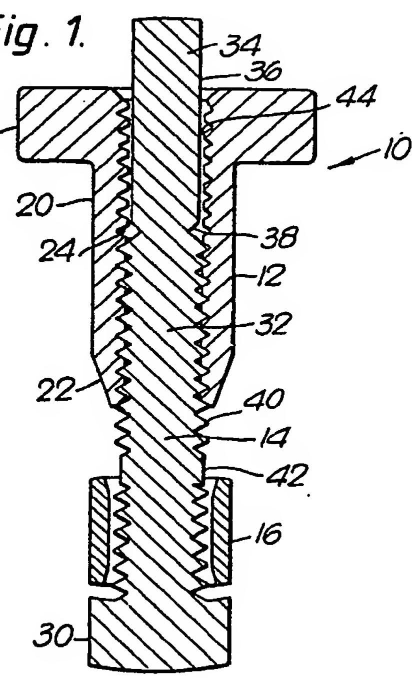
(54) **Locking of blind fasteners**

(57) A blind fastener 10 comprises a bolt 14 having a breakneck 38 for limiting the torque transmissible therethrough; a tubular nut 12 having a head; and a tubular sleeve 16 which, by turning the bolt in the nut, is forced on to the shank of the nut and expanded to form a blind head, the bolt thread 40 being provided with a cylindrical locking zone 42 which has a diameter intermediate the diameters of the crests of the nut and bolt threads 24 and 40, and the nut thread 24 being reamed to provide a crest surface forming part of a truly cylindrical surface of smaller diameter than the locking zone 42 of the bolt 14 to give a controlled interference between the locking zone 42 and the nut thread 24 which serves to lock the nut and bolt together.

Fig. 1.



The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

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Fig. 1.

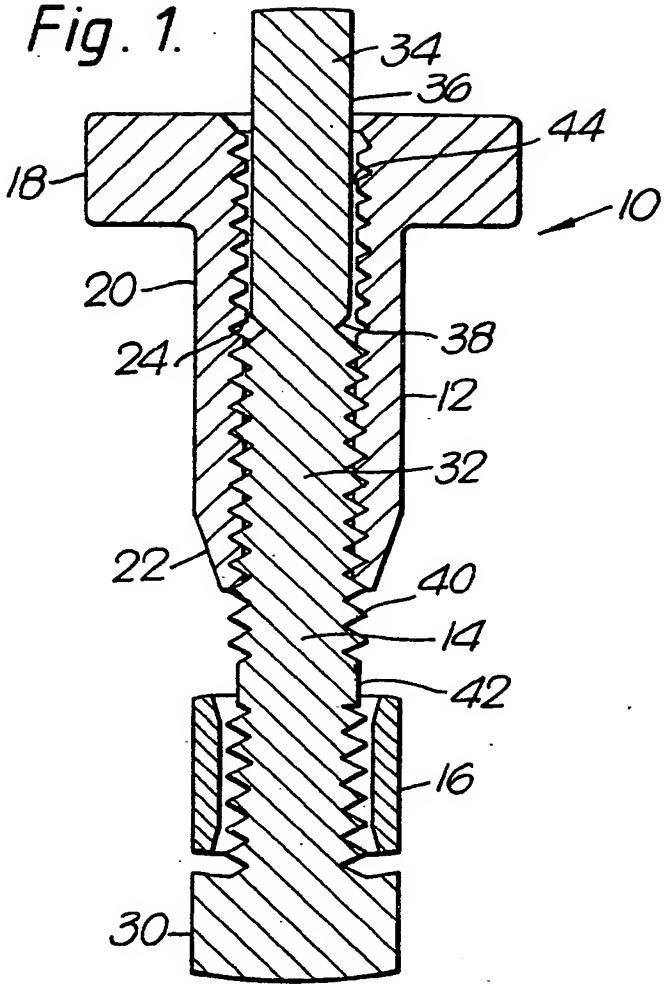


Fig. 2.

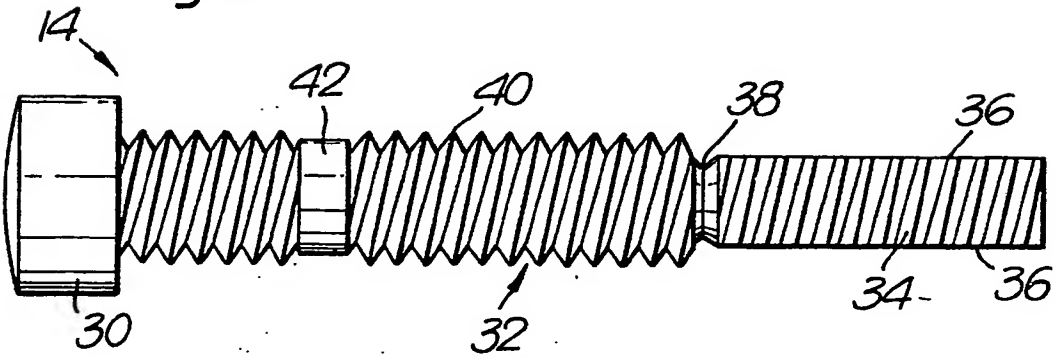


Fig.3.

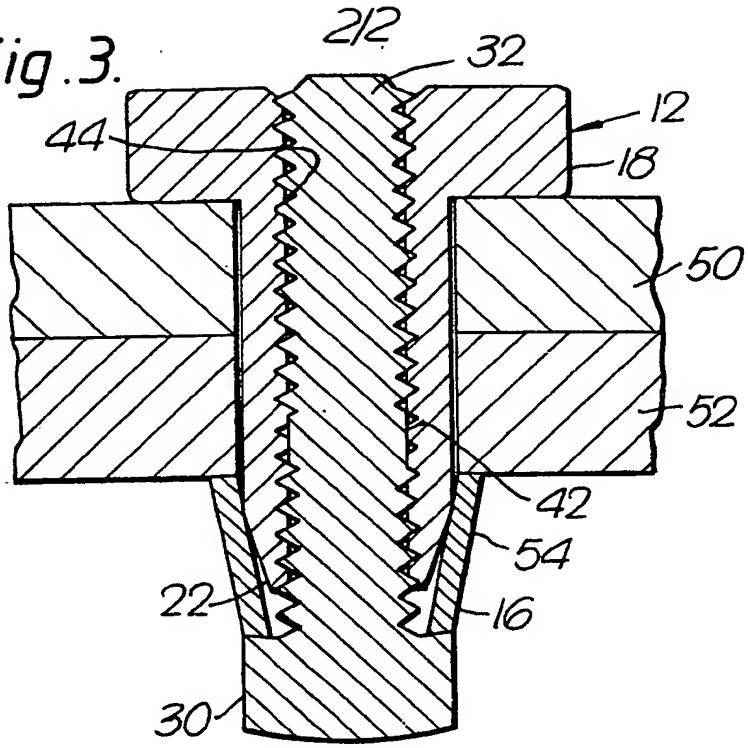
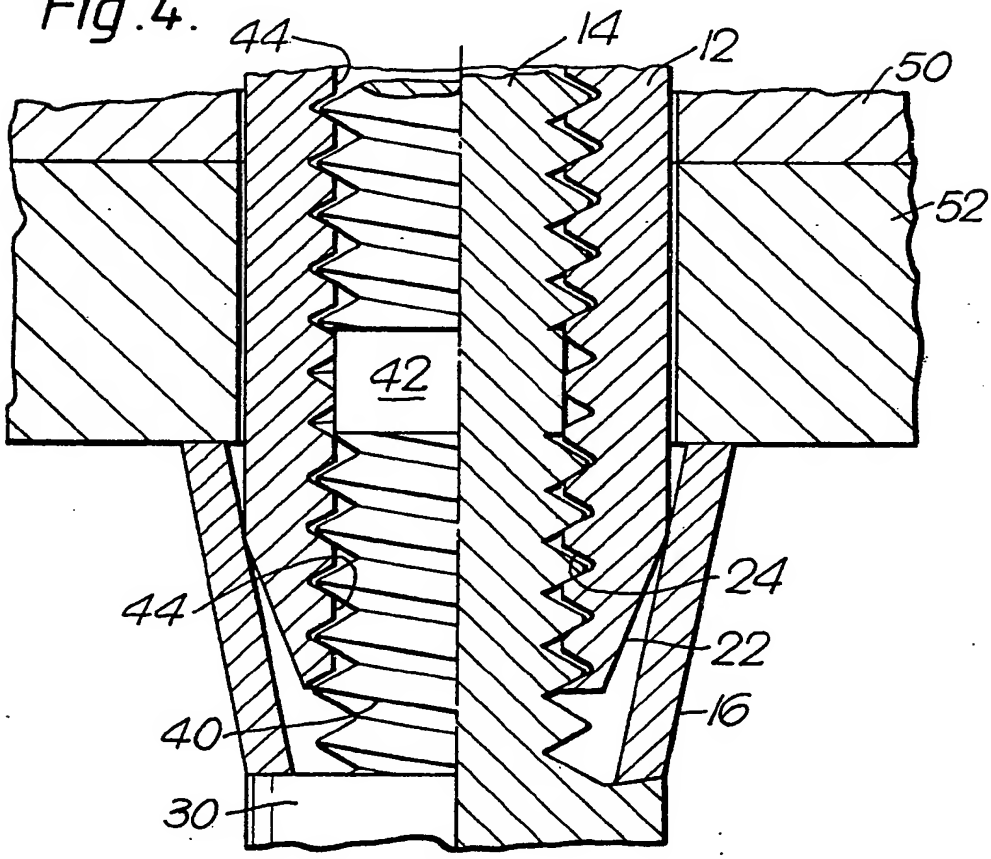


Fig.4.



SPECIFICATION
A blind fastener

This invention relates to a self-locking blind fastener and more particularly to a blind fastener of the kind comprising three main parts, namely a screw-threaded head bolt, a nut having a female screw thread for mating engagement with the thread of the bolt and having a shank and an enlarged head, the shank providing a nose which tapers towards the end remote from the head and a sleeve which can be expanded to form a blind head by screwing the bolt through the nut so that the bolt head abuts the sleeve and forces it onto the tapered nose of the nut.

Prior to use, the parts are assembled, the bolt being inserted into the sleeve and then screwed into the end of the nut remote from the nut head until it projects from the head end of the nut. In use, the shank of the nut is inserted through aligned holes in workpiece sheets to be fastened together so that the head of the nut abuts one side of the work-piece and the tapered nose projects beyond the opposite side. The fastener is set by rotating the bolt relative to the nut so that, by virtue of the threaded engagement between the nut and bolt, the head of the bolt is advanced towards the shank of the nut, forcing the sleeve over the tapered nose and thereby causing the sleeve to be expanded to form a blind head which is held in abutment with the said opposite side of the workpiece by the bolt head.

In one form of blind fastener of the type referred to, the stem of the bolt is provided with a breaker groove at which the diameter of the stem is reduced to a breakneck at which the stem will break when subjected to a predetermined torque. The breaker groove demarcates the bolt into a main part which includes the bolt head and adjacent threaded portion of the stem, and a break-off portion of the stem, remote from the bolt head. The break-off portion is arranged to project from the headend of the nut prior to setting the fastener so that the bolt can be gripped and rotated relative to the nut to set the fastener. It will be appreciated that the torque required to turn the bolt relative to the nut increases as the expansible sleeve is forced further on to the shank of the nut and as any workpiece clamped between the head of the nut and the blind head formed by the expanded sleeve is compressed, and eventually the required torque exceeds that substainable by the breakneck so that the bolt stem breaks at the breakneck, leaving the main part of the bolt as an integral part of the set fastener, and the break-off portion is discarded.

Blind fasteners of such a kind are used in the aerospace industry for the assembly of parts of aircraft and space vehicles, and, in recent years, there has arisen a demand for such fasteners to be provided with self-locking threads in order to reduce the risk of the nut and bolt becoming unscrewed in use as can happen as a result of stress and vibration over prolonged periods of time.

Many kinds of self-locking thread arrangements have been proposed and used for nut and bolt type fasteners but few are suitable for blind fasteners of the kind referred to above. There are two main reasons for this. First, the strength of the lock obtainable has to meet certain minimum requirements and it is also generally found that, the stronger the lock required, the greater the force needed to engage the lock. However, the amount of torque available for engaging the lock in blind fasteners of the kind referred to is limited to that which can be transmitted by the breakneck of the bolt which in turn has necessarily to be limited and controlled within a fairly precise range in order to ensure that the fastener can be set and clamp the members of a work piece together sufficiently tightly and for the bolt then to break at the breakneck so as to avoid over-tightening of the fastener which could result in failure of a different kind.

It will therefore be appreciated that while the torque required to engage the lock cannot be allowed to approach too closely to that required to set the fastener and break the bolt, the necessarily lower torque required to overcome the lock, which represents the effectiveness of the lock, must be as high as possible. Moreover, in manufacturing the blind fasteners careful control must be exerted in order to ensure minimum variation between the various torque values concerned.

We have now devised a blind fastener of the kind referred to which effectively meets the requirements of the market for a self-locking capability and which can be manufactured to tolerances which are easily controlled so as to provide consistent performance as between one fastener and another.

According to the present invention there is provided a blind fastener comprising a screw-threaded, headed, bolt, a nut having a female screw-thread for matingly engaging the screw thread of the bolt and having a shank providing a tapered nose and an enlarged head, and a sleeve which can be forced onto the tapered nose of the shank of the nut by screwing the nut along the bolt towards the head thereof and thereby expanded to form a blind head, wherein the bolt has a substantially cylindrical locking zone, the diameter of the bolt in the locking zone being intermediate between the crest diameter of the screw thread of the bolt and the crest diameter of the thread of the nut, the locking zone extending axially through a distance greater than the pitch of the thread;

at least that part of the nut thread which will, in use of the fastener, be traversed by the locking zone of the bolt having a crest the surface of which forms part of a truly cylindrical surface having a lesser diameter than the diameter of that helical strip upon the surface of the locking zone of the bolt with which the aforesaid crest surface will engage, whereby when the nut is screwed along the bolt to set the fastener the crest surface of the nut thread interferes to a predetermined

extent with the locking zone along the helical strip and provides a controlled interference giving a frictional lock between the nut and bolt.

The locking zone may be spaced from the head of the bolt by a distance equal to at least twice the pitch of the bolt thread.

The locking zone of the bolt may have a diameter equal to or slightly greater than the effective diameter of the bolt thread. Preferably the diameter of the locking zone is not less than the effective diameter of the bolt thread.

Preferably, the interference between the crest surface of the nut thread and the locking zone is such as to be insufficient to cause plastic deformation of the nut thread.

The said interference may be within the range 0.025 mm to 0.1016 mm and preferably is within the range 0.0381 mm to 0.0762 mm.

The truly cylindrical form of the crest surface of the said part of the nut thead may be formed by an accurate dimensioning operation performed subsequent to forming the thread of the nut.

The nut thread may be formed by a cutting or roll tapping operation and the said part thereof may be a subsequently reamed portion thereof.

The mating surfaces of the nut and or the bolt may have a lubricant coating thereon.

The lubricant coating may be a plating of a lubricant metal such as cadmium.

Preferably the locking zone is intermediate between the ends of the screw thread.

The locking zone may be formed as a cylindrical portion of sufficient diameter to interfere with the crest of the thread of the nut without causing appreciable plastic deformation of the thread of the nut.

Preferably, the locking zone of the bolt extends axially through a distance equal to at least twice and not greater than four times the pitch of the screw thread of the bolt.

A preferred form of the invention will now be described with reference to the accompanying drawings in which:—

Figure 1 is a sectional elevation of a blind fastener embodying the invention;

Figure 2 is an elevation of the bolt part of the fastener of Figure 1;

Figure 3 is a sectional elevation of an assembly, illustrating the fastener of Figure 1 in use, and

Figure 4 is an enlarged fragmentary elevation, partly in section, of the assembly of Figure 3.

Referring first to Figure 1 of the drawings, a blind fastener 10 comprises a nut 12, a bolt 14 and a sleeve 16.

The nut 12 comprises a hexagonal head 18 and an elongate shank 20 having an end portion 22 remote from the head and tapered away from the head to form a conical nose. The nut is, of course, tubular and is formed with an internal screw thread 24 throughout the length of its bore.

The sleeve 16 is a tubular cylinder having an external diameter substantially equal to that of the shank of the nut and has a bore which is flared at both ends, the flared ends each reaching slightly greater internal diameter than the smallest diameter of the tapered nose 22 of the nut so that the nose 22 can easily enter either of the flared ends.

The bolt 14 is a head 30 at one end of diameter substantially equal to that of the shank of the nut, and an elongate stem 32 of greater axial length then the combined lengths of the nut 12 and sleeve 16. A break-off wrenching portion 34 of the bolt stem most remote from the head 30 is provided with a pair of diametrically opposed wrenching flats 36 whereby the bolt may be rotated, and the portion 34 is joined to the remainder of the stem 32 by a breakneck 38 at which the stem may the broken at a predetermined torque, enabling the wrenching portion 34 to be detached from the installed fastener as illustrated in Figure 3.

A screw thread 40 which is generally complementary to the screw thread 24 of the nut so as to matingly engage the nut thread, extends throughout the length of the bolt stem 32, except in a locking zone 42 and over the surfaces of the breackneck and wrenching flats. The locking zone 42 is spaced from the head of the bolt by a distance approximately equal to the length of the sleeve 16. The locking zone 42 is in the form of an unthreaded cylindrical land accurately concentric with the axis of the bolt thread and having a diameter which is greater than the crest diameter of the complementary thread of the nut and which is less than the diameter of the stem taken across the crest of the thread on the bolt. The land 42 extends axially through a distance which is equal to twice the pitch of the thread 40. It is not objectionable if the surface of the land has a raised vestige of thread provided that the land has a helical path over which the mating thread of the nut can pass which path has a surface which is part of a cylinder concentric with the axis of the bolt thread.

Moreover, at least that part of the thread 24 of the nut which, in use of the fastener, will be traversed by the locking zone of the bolt has a flattened crest 44. As shown in the drawings, the entire length of the nut thread has a flattened crest since this is more convenient to achieve in the manufacturing process than over a limited length of the thread. In particular, it is here stressed that the flattened crest of the nut thread is formed with precision so that the surface of the crest is part of a truly cylindrical surface.

The mating threads of the nut and bolt in this embodiment are basically of the form known as Unified National Fine and as is well known, the basic form of this thread has a flattened crest, although in normal manufacture it is usual to tolerate some rounding especially of the longitudinal edges of the crest.

However in forming the nut of the invention we take special steps to ensure that the crest of the nut thread is truly cylindrical and free from burrs and irregularities such as are normally formed in manufacture by tapping or thread rolling and to this end we first form the thread in a normal manner by means of a cutting tap, and then ream

at least that portion which will be traversed by the locking zone of the bolt so as to remove a portion of the crest of the thread and leave a truly cylindrical crest surface.

Furthermore, the nut thread is reamed to a minor diameter such that the crest will interfere with the cylindrical surface of the land of the bolt to a predetermined extent within close tolerances. More specifically the amount of interference is arranged to be such that the deformation of the thread of the nut when engaged with the locking zone of the bolt is within the elastic limit of the material of the nut so that the nut thread is not caused to undergo any plastic deformation.

Thus, in this embodiment, both the nut and the bolt are formed of steel, and the shank of the nut has a nominal external diameter of 4.83 mm. The mating threads of the nut and bolt have the form of 6 — 40 UNF with an effective diameter for the bolt thread of 3.02 mm. The cylindrical land of the locking zone of the bolt has a diameter which is made the same as (or can be very slightly greater than) the effective diameter, and the thread of the nut is reamed to a minor diameter so as to interfere with the land of the bolt and with a precision such that the interference is within the range of 0.038 mm to 0.076 mm.

Prior to use, the blind fastener 10 is assembled so that the cylindrical sleeve 16 is disposed on the stem of the bolt 14 adjacent the head 30, and the stem of the bolt is entered into threaded engagement with the nut 12 so that the conical nose 22 at the end of the nut 12 just reaches the nearer end of the locking zone 42 on the bolt. The wrenching portion 34 of the bolt then projects beyond the head 18 of the nut.

Referring to Figures 3 and 4, in use of the blind fastener 10, the bolt head 30, sleeve 16, and nut shank 20 are inserted through aligned holes in workpiece members 50, 52 to be joined together so that the head 18 of the nut abuts a surface of the member 50, and the head of the bolt, the sleeve and the conical nose of the nut shank project beyond the face of the other member 52 remote from the head of the nut. The nut 12 and bolt 14 are then relatively rotated, conveniently using the wrenching flats 36 of the bolt and hexagonal form of the head of the nut 18 to obtain a suitable grip, so as to bring the head 30 of the bolt nearer to the head 18 of the nut. In doing so, the sleeve 16 is forced over the conical nose 22 of the nut shank and thereby expanded to form a blind head 54 which abuts the adjacent face of the workpiece member 52 and causes the two workpiece members to be tightly clamped between the blind head 54 and the head 18 of the nut.

Once the workpiece members 50, 52 are tightly clamped between the head 18 of the nut and the blind head 54, the force required to rotate the bolt further relative to the nut exceeds that which can be sustained by the breakneck 38 and the bolt stem breaks at the breakneck allowing the wrenching portion to be discarded, leaving the set fastener in the condition illustrated in Figure 3.

In entering the bore of the nut, the locking zone of the bolt interferes with the thread of the nut, producing some elastic deformation of the nut. However, due to the close tolerances within which the locking zone and the reamed thread of the nut are formed, neither the locking zone nor the nut thread undergo any plastic deformation and no galling occurs. The friction between the interfering surfaces of the nut thread and the locking zone obtained with the prescribed amount of interference for this embodiment (namely 0.038—0.076 mm) is low enough to enable the fastener to apply an adequate clamping pressure to the workpiece members which, as previously explained, is limited by the torque transmissible by the breakneck, but sufficient to ensure that the fastener will not become unscrewed even under rigorous conditions of use.

Other similar fasteners have been made with dimensions differing from those of the foregoing example. In all those tried, it has been found that the dimensions of the fastener can be varied slightly but that the interference between the crest surface of the nut thread and the locking zone should always be within a broad range of 0.025 mm to 0.1016 mm. There is however, an overriding need to avoid the interference being so great that the bolt will break before the fastener has clamped the workpiece members together, and also the interference ought not to be so great that plastic deformation occurs at the interfering surfaces. The friction between the interfering surfaces reaches a maximum once the locking zone has entered fully into engagement with the nut thread and does not increase as the locking zone passes further along the nut thread.

Similarly, once the fastener has been set, the torque required to turn the bolt in a direction to unscrew the bolt from the nut remains constant as long as the locking zone of the bolt is entirely within and engaged by the nut thread. Consequently, and especially in order to meet user requirements for a thread lock which maintains a predetermined strength of locking after the bolt has been unscrewed through up to two full turns, we arrange the locking zone of the bolt at a position so spaced from the head of the bolt that when the fastener is fully set, the locking zone has entered the nut and passed beyond at least two full turns of the nut thread.

In order that the transverse width across the flattened crest of the nut thread is great enough to have substantial resistance to plastic deformation when interfered with by the locking zone of the bolt, we arrange that the diameters of the locking zone of the bolt and the crest of the nut thread are such as to interfere with each other at a diameter which is substantially the same as or slightly greater than the effective diameter of the bolt thread, but not so great that the height of the crest of the nut thread above its root is so small as to render the nut thread of inadequate strength to strongly engage the thread of the bolt.

After manufacturing the parts of the blind fastener to the dimensions and tolerances referred

to above, the parts are then provided with a coating in the form of an electrolytically deposited layer of cadmium to serve as both a lubricant coating on the surfaces of the frictionally engaging parts and the interfering parts and to act as a rust proofing coating.

CLAIMS

1. A blind fastener comprising

a screw-threaded, headed, bolt;

a nut having a shank, an enlarged head and a female screw-thread for matingly engaging the screw thread of the bolt, the shank of the nut providing a nose which tapers towards the end remote from the head of the nut; and

a sleeve which can be forced onto the tapered nose of the shank of the nut by screwing the nut along the bolt towards the head of the bolt, and thereby expanded to form a blind head;

wherein the bolt has a substantially cylindrical locking zone, the diameter of the bolt in the locking zone being intermediate between the crest diameter of the screw thread of the bolt and the crest diameter of the thread of the nut, the locking zone extending axially through a distance greater than the pitch of the thread; and at least that part of the nut thread which will, in use of the fastener, be traversed by the locking zone of the bolt has a crest the surface of which forms part of a truly cylindrical surface having a lesser diameter than the diameter of that helical strip upon the surface of the locking zone of the bolt with which the aforesaid crest surface will engage, the arrangement being such that, when the nut is screwed along the bolt to set the fastener, a predetermined interference will occur between the crest surface of the nut thread and the locking zone along the helical strip and provide a frictional lock between the nut and bolt.

2. A blind fastener according to claim 1, wherein the locking zone is spaced from the head of the bolt by a distance equal to at least twice the pitch of the bolt thread.

3. A blind fastener according to either of claims 1 or 2, wherein the locking zone is intermediate between the ends of the screw thread of the bolt.

4. A blind fastener according to any preceding claim, wherein the locking zone of the bolt extends axially through a distance equal to at least twice and not greater than four times the pitch of the screw thread of the bolt.

5. A blind fastener according to any preceding claim, wherein the locking zone is a cylindrical portion accurately concentric with the axis of the thread of the bolt.

6. A blind fastener according to any preceding claim, wherein the diameter of the locking zone of the bolt is not less than the effective diameter of the bolt thread.

7. A blind fastener according to any preceding claim, wherein the locking zone of the bolt has a diameter equal to or slightly greater than the effective diameter of the bolt thread.

8. A blind fastener according to any preceding claim, wherein the interference between the crest surface of the nut thread and the locking zone is insufficient to cause plastic deformation of the nut thread.

9. A blind fastener according to any preceding claim, wherein the interference is within the range 0.025 mm to 0.1016 mm.

10. A blind fastener according to any preceding claim, wherein the interference is within the range 0.0381 mm to 0.0762 mm.

11. A blind fastener according to any preceding claim, wherein the truly cylindrical form of the crest surface of the said part of the nut thread is formed by an accurate dimensioning operation performed subsequent to forming the thread of the nut.

12. A blind fastener according to any preceding claim, wherein the nut thread is formed by a cutting or roll tapping operation and the said part thereof is a subsequently reamed portion thereof.

13. A blind fastener according to any preceding claim, wherein the mating surfaces of the nut and or the bolt have a lubricant coating thereon.

14. A blind fastener according to claim 13, wherein the lubricant coating is a plating of a lubricant metal such as cadmium.

15. A blind fastener according to any preceding claim, wherein the bolt has a breakneck spaced away from the bolt head beyond the locking zone, the breakneck having a strength adequate to set the fastener but not to overtighten the fastener.

16. A blind fastener substantially as hereinbefore described with reference to, and illustrated in, the accompanying drawings.

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